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Neural Gas Containing Two Kinds of Neurons

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1. Introduction

Recently, the Neural Gas network[1] has attracted attention as a image-recognition technology. In the learning, Neural Gas uses one type of neurons. However, in the real world, an elephant, which has a slow heart rate, and a mouse, which has a rapid heart rate, have different senses of time. In this study, we propose a new Neural Gas algorithm; Neural Gas containing two kinds of neurons. One converges rapidly, and the other converges slowly.

2. Algorithm of Proposed Method

We explain the algorithm of the proposed method. The proposed method has two kinds of neurons; A_1 and A_2, whose features are different. The set A_1 contains m_1 neurons, and the A_2 contains m_2 neurons. Therefore, the network consists of a set A containing $M = m_1 + m_2$ neurons; $A = \{c_1, c_2, \cdots, c_M\}$. The neurons of the set A are classified into A_1 and A_2 at random. Each neuron c_i has a d-dimensional weight vector $\boldsymbol{w}_i = (w_{i1}, w_{i2}, \cdots, w_{id})$ $(i = 1, 2, \cdots, M)$. The initial values of the weight vectors are given at random. The range of the elements of d-dimensional input data $\boldsymbol{x}_j = (x_{j1}, x_{j2}, \cdots, x_{jd})$ $(j = 1, 2, \cdots, N)$ are assumed to be from 0 to 1.

(TK-NG1) Euclid distances d_{ji} between an input vector $\boldsymbol{x}_j$ and all the weight vectors $\boldsymbol{w}_i$ are calculated;

$$d_{ji} = \|\boldsymbol{x}_j - \boldsymbol{w}_i\|. \quad (1)$$

(TK-NG2) Each neuron c_i is assigned a rank $k = 0, \cdots, (M-1)$ depending on their d_{ji}. The rank of 0 indicates the neuron closest to $\boldsymbol{x}_i$ and the rank of $(M-1)$ indicates the neuron farthest from $\boldsymbol{x}_i$.

(TK-NG3) The weight vectors of the neurons are updated according to

$$\boldsymbol{w}_i(t+1) = \boldsymbol{w}_i(t) + E(t) h_\lambda(t)(\boldsymbol{x}_j - \boldsymbol{w}_i(t)), \quad (2)$$

where $E(t)$ is the learning rate;

$$E(t) = E_i \left(\frac{E_i}{E_f} \right)^{\frac{t}{T}}, \quad (3)$$

where t is the time step and T is the total number of training steps. E_i and E_f are the initial and the final values of $E(t)$, respectively. $h_\lambda(t)$ is the neighborhood ranking function described as;

$$h_\lambda(t) = \exp(-k/\lambda(t)), \quad (4)$$

where the parameter $\lambda(t)$ controls the width of the neighborhood function;

$$\lambda(t) = \begin{cases} \lambda_i \left(\frac{\lambda_f}{\lambda_i} \right)^{\frac{t}{T}}, & c_i \in A_1 \\ \lambda_i \left(1 - \frac{t}{T} \right) + \lambda_f \frac{t}{T}, & c_i \in A_2, \end{cases} \quad (5)$$

where λ_i and λ_f are the initial and the final values of $\lambda(t)$, respectively. As a result of Eq. (5), λ of A_1 decreases rapidly. On the other hand, the parameter λ of A_2 decreases linearly. In other words, the neurons of A_1 converge rapidly, and the neurons of A_2 converge slowly.

(TK-NG4) If $t < T$, return to (TK-NG1).

3. Computer Simulation

We consider 2-dimensional input data as shown in Fig. 1(a). The input data has 1 cluster and noises. There are 700 points in the cluster and 300 points for noises. The simulation result of the conventional Neural Gas is shown in Fig. 1(b). We can see that there are some neurons not only inside of the cluster but also outside. The other side, the result of the proposed Neural Gas is shown in Fig. 1(c). We confirm that there are A_2 neurons in the cluster and A_1 neurons are outside of the cluster. In other words, proposed method learns by using different kind of neurons in the cluster and noises, while conventional method uses only one kinds of neurons. We can see from this figure that the proposed Neural Gas holds the possibility to an application to the noise reduction.

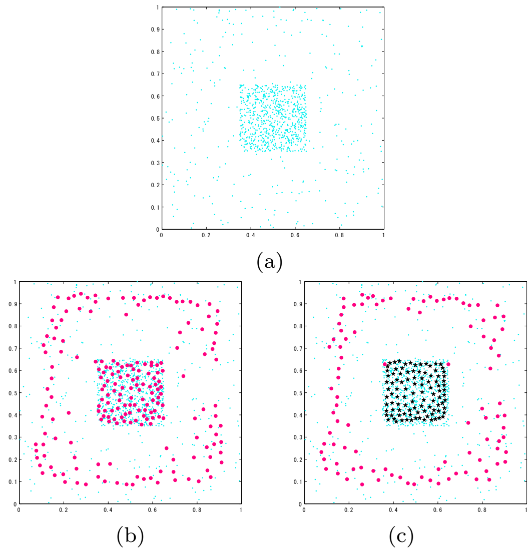

Figure 1: Learning simulation for 2-dimensional input data. (a) Input data. (b) Result of conventional Neural Gas. (c) Result of proposed Neural Gas.

4. Conclusions

We have proposed a new Neural Gas algorithm; Neural Gas containing two kinds of neurons. We have confirmed that there was the possibility of application to the noise reduction by using two kinds of neurons.

Reference

[1] T. M. Martinetz and K. J. Schulten, "Neural-gas network learns topologies. In T. Kohonen, K. Makisara, O. Simula, and J. Kangas, editors", *Artifical Neural Networks*, pp. 397-402, 1991.